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Five months since a belated arrival at Venus, Japan’s Akatsuki spacecraft has officially started a modified scientific survey of the sweltering, shrouded planet’s atmosphere and climate.

The probe’s science cameras are collecting regular images of Venus’s exotic clouds, and Japanese engineers are optimistic Akatsuki can remain operational for at least two years, and perhaps through 2020.

Akatsuki braked into orbit around Venus in early December, five years later than originally planned after it missed an arrival opportunity in 2010.

Scientists checked out the orbiter’s science instruments since the craft arrived at Venus, and declared Akatsuki operational in April, according to the Japan Aerospace Exploration Agency. One of the spacecraft’s instruments, the lightning and airglow camera, is still being calibrated before it shifts to regular observations, JAXA said.

Launched by a Japanese H-2A rocket in May 2010, Akatsuki survived an unplanned five-year cruise to Venus, passing closer to the sun and withstanding higher temperatures it was designed to endure after a propulsion failure thwarted an orbit insertion burn in December 2010.

A salt formation blocked an engine valve, starving Akatsuki’s main thruster of fuel during the critical firing to swing into orbit around Venus.

Five years later, when Akatsuki was again in the vicinity of Venus, the spacecraft fired its secondary attitude control thrusters to steer into orbit. But the smaller engines had less power than the probe’s primary thruster, driving Akatsuki into an orbit stretching nearly five times farther from Venus than originally intended.

A course correction burn April 4 slightly adjusted Akatsuki’s orbit to reach a peak altitude of 370,000 kilometers (about 230,000 miles), roughly the distance between the Earth and the moon. At the low end of its orbit, Akatsuki passes between 1,000 and 10,000 kilometers (620-6,200 miles) above Venus’s cloud tops.

The higher orbit will complicate the mission’s scientific observations, with Venus appearing much smaller to Akatsuki’s cameras. It also produces fewer opportunities for radio occultation measurements, which use radio signals passed between the spacecraft and Earth-based antennas to study the vertical structure of Venus’s atmosphere.

The orbiter’s lightning and airglow camera, conceived to take the first pictures of lightning flashes on Venus, can only collect images for about one hour during each 10.8-day orbit, when Akatsuki is in the shadow of the planet. The limited imaging windows for the lightning camera have extended the instrument’s calibration time, but scientists expect it to begin full science observations in June.

Takeshi Imamura, Akatsuki’s project scientist at JAXA’s Institute of Space and Astronautical Science, told a gathering of planetary scientists in Britain last month that the mission’s shortcomings could be overcome with more high-resolution imaging at the low point of Akatsuki’s orbit, and an extension of the probe’s operations beyond its original two-year lifetime through 2020.
Akatsuki, which means dawn in Japanese, is the only mission currently operating at Venus. It is also Japan’s first spacecraft to orbit another planet.

The craft is the first Venus mission dedicated to unraveling the planet’s complex atmosphere, with high-altitude super-rotating jet streams, thick clouds made of sulfuric acid and a blanket of heat-trapping carbon dioxide, driving surface temperatures to 900 degrees Fahrenheit (480 degrees Celsius), hot enough to melt lead.

Akatsuki carries three infrared cameras, each tuned to resolve a different layer in Venus’s atmosphere.

One of the imagers can see deep into the planet’s shroud of clouds and toxic haze to see Venus’s surface terrain. An early picture from the camera revealed Aphrodite Terra, a highland region near the planet’s equator so far only observed by radar surveys.

Another sensor in longwave infrared can detect the temperature of Venus’s cloud tops, while a two-micron imaging channel is suited for observations of the planet’s night side.

Akatsuki beamed back the most detailed global image ever captured of Venus’s night side clouds March 25. The six-second exposure, posted above, reveals previously unseen wave and stripe patterns.

“This is to date the most detailed global view of the night-side disk,” JAXA wrote in a description accompanying the image. “At 2.26 microns, spatially-inhomogeneous clouds appear as silhouette back-illuminated by thermal radiation from the hot lower atmosphere. Such images, combined with other cameras’ data, will be used to study the 3D structure and dynamics of Venus atmosphere.”

The longwave infrared camera spotted an unexpected bow-shaped cloud stretching thousands of kilometers running from the northern hemisphere to the southern hemisphere of the planet.

“This is the first time to learn (of) such a phenomenon,” JAXA said in a statement.

An ultraviolet camera aboard Akatsuki can help scientists study the origin of the planet’s clouds and track weather patterns as they move around the planet with jet stream winds moving at up to 400 kilometers per hour (250 mph).

Imamura said the processes responsible for the formation of Venus’s sulfuric acid clouds seem to be much more complicated than expected.

Scientists plan near-continuous global imaging throughout Akatsuki’s mission, plus closeups when the spacecraft is near Venus, occasional searches for lightning and atmospheric profile measurements with the probe’s radio science platform.

Source: Spaceflight Now
New Horizons Collects First Science on a Post-Pluto Object

Warming up for a possible extended mission as it speeds through deep space, NASA’s New Horizons spacecraft has now twice observed 1994 JR1, a 90-mile-wide (145-kilometer-wide) Kuiper Belt object (KBO) orbiting more than 3 billion miles (5 billion kilometers) from the sun. Science team members have used these observations to reveal new facts about this distant remnant of the early solar system.

Taken with the spacecraft’s Long Range Reconnaissance Imager (LORRI) on April 7-8 from a distance of about 69 million miles (111 million kilometers), the images shatter New Horizons’ own record for the closest-ever views of this KBO in November 2015, when New Horizons detected JR1 from 170 million miles (280 million kilometers) away.

Simon Porter, a New Horizons science team member from Southwest Research Institute (SwRI) in Boulder, Colorado, said the observations contain several valuable findings. “Combining the November 2015 and April 2016 observations allows us to pinpoint the location of JR1 to within 1,000 kilometers (about 600 miles), far better than any small KBO,” he said, adding that the more accurate orbit also allows the science team to dispel a theory, suggested several years ago, that JR1 is a quasi-satellite of Pluto.

From the closer vantage point of the April 2016 observations, the team also determined the object’s rotation period, observing the changes in light reflected from JR1’s surface to determine that it rotates once every 5.4 hours (or a JR1 day). “That’s relatively fast for a KBO,” said science team member John Spencer, also from SwRI. “This is all part of the excitement of exploring new places and seeing things never seen before.”

Spencer added that these observations are great practice for possible close-up looks at about 20 more ancient Kuiper Belt objects that may come in the next few years, should NASA approve an extended mission. New Horizons flew through the Pluto system on July 14, 2015, making the first close-up observations of Pluto and its family of five moons. The spacecraft is on course for an ultra-close flyby of another Kuiper Belt object, 2014 MU69, on Jan. 1, 2019.

Source: NASA
3. Van Allen Probes Reveal Long-term Behavior of Earth’s Ring Current

New findings based on a year’s worth of observations from NASA’s Van Allen Probes have revealed that the ring current - an electrical current carried by energetic ions that encircles our planet - behaves in a much different way than previously understood.

The ring current has long been thought to wax and wane over time, but the new observations show that this is true of only some of the particles, while other particles are present consistently. Using data gathered by the Radiation Belt Storm Probes Ion Composition Experiment, or RBSPICE, on one of the Van Allen Probes, researchers have determined that the high-energy protons in the ring current change in a completely different way from the current’s low-energy protons. Such information can help adjust our understanding and models of the ring current which is a key part of the space environment around Earth that can affect our satellites. The findings were published in Geophysical Research Letters.

"We study the ring current because, for one thing, it drives a global system of electrical currents both in space and on Earth’s surface, which during intense geomagnetic storms can cause severe damages to our technological systems," said lead author of the study Matina Gkioulidou, a space physicist at the Johns Hopkins University Applied Physics Laboratory in Laurel, Maryland. "It also modifies the magnetic field in the near-Earth space, which in turn controls the motion of the radiation belt particles that surround our planet. That means that understanding the dynamics of the ring current really matters in helping us understand how radiation belts evolve as well."

The ring current lies at a distance of approximately 6,200 to 37,000 miles (10,000 to 60,000 km) from Earth. The ring current was hypothesized in the early 20th century to explain observed global decreases in the Earth’s surface magnetic field, which can be measured by ground magnetometers. Such changes of the ground magnetic field are described by what’s called the Sym-H index.

"Previously, the state of the ring current had been inferred from the variations of the Sym-H index, but as it turns out, those variations represent the dynamics of only the low-energy protons," said Gkioulidou. "When we looked at the high-energy proton data from the RBSPICE instrument, however, we saw that they were behaving in a very different way, and the two populations told very different stories about the ring current."

The Van Allen Probes, launched in 2012, offer scientists the first chance in recent history to continuously monitor the ring current with instruments that can observe ions with an extremely wide range of energies. The RBSPICE instrument has captured detailed data of all types of these energetic ions for several years. "We needed to have an instrument that measures the broad energy range of the particles that carry the ring current, within the ring current itself, for a long period of time," Gkioulidou said. A period of one year from one of the probes was used for the team's research.

"After looking at one year of continuous ion data it became clear to us that there is a substantial, persistent ring current around the Earth even during non-storm times, which is carried by high-energy protons. During geomagnetic storms, the enhancement of the ring current is due to new, low-energy protons entering the near-Earth region. So trying to predict the storm-time ring current enhancement while ignoring the substantial preexisting current is like trying to describe an elephant after seeing only its feet," Gkioulidou said.
The Night Sky

Friday, May 20
• The nearly full Moon looms low in the east-southeast at sunset and shines above Mars as twilight fades. How soon can you pick out Mars? How much later will it be until you can pick out fainter Antares, rising $8{1/2}^\circ$ below Mars?

And what about Saturn, $7{1/2}^\circ$ left of Antares? Saturn and Antares rise at the same time if you're near $35^\circ$ N latitude (North Carolina, central California). If you're north of there Saturn rises first; south of there, Antares.

And how soon can you spot the second-brightest star in this area? It's Delta Scorpii, now just $1^\circ$ below Mars. That's less than a finger-width at arm's length.

Saturday, May 21
• Mars is at opposition tonight, opposite the Sun as seen from Earth. It's almost at its closest to Earth for this apparition, though not exactly so until the 30th.

• Full Moon this evening; by coincidence, the Moon and Mars are both at opposition. The Moon forms a rough rectangle with Mars to its right or lower right, Antares farther below it, and Saturn to its lower left, as shown above (seen from North America). Think photo opportunity.

Sunday, May 22
• The Moon now rises in twilight with Saturn about $4^\circ$ to its right (as seen from North America). Mars and Antares are farther to their right, as shown above.

Monday, May 23
• As spring grows late, the "Spring Star" Arcturus shines very high in the southeast after dark (very high over Mars). The "Summer Star" Vega, equally bright, dominates the sky lower toward the east-northeast.

Arcturus is a type-K1.5 giant and thus shines pale orange-yellow, like a drop of rich ginger ale. Below Mars is Antares, an M1.5 supergiant with a deeper fire color than Arcturus. Mars currently looks much yellower than Antares, at least to my eyes, but that's probably because it's so much brighter. Brightness makes any color look desaturated (more toward white) — an illusion of human color vision and camera chips too.

• Jupiter's Great Red Spot transits Jupiter's central meridian around 10:45 p.m. EDT. It's positioned in excellent view for an hour before and after it transits.

Tuesday, May 24
• Jupiter's moon Europa crosses Jupiter's face tonight from 9:24 p.m. to 12:12 a.m. EDT, followed by its especially tiny black shadow from 11:57 p.m. to 2:40 a.m. EDT. (Subtract 3 hours to get PDT.)

Source: Sky & Telescope
## ISS Sighting Opportunities

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Sighting information for other cities can be found at NASA's [Satellite Sighting Information](https://nssdc.gsfc.nasa.gov/planetary/iss/issnii.html).

### NASA-TV Highlights

(All times Eastern Daylight Time)

**10 a.m., Tuesday, May 24** - ISS Expedition 47 In-Flight Interview with CNN International and Christiane Amanpour with Flight Engineer Tim Peake of the European Space Agency (all channels)

Watch NASA TV on the Net by going to the [NASA website](https://www.nasa.gov/).
Space Calendar

- May 20 - Comet 78P/Gehrels At Opposition (4.282 AU)
- May 20 - Apollo Asteroid 2016 JT28 Near-Earth Flyby (0.064 AU)
- May 20 - Apollo Asteroid 2016 JF18 Near-Earth Flyby (0.093 AU)
- May 20 - Asteroid 2873 Binzel Closest Approach To Earth (0.938 AU)
- May 20 - Asteroid 9025 Polansky Closest Approach To Earth (2.064 AU)
- May 20 - Asteroid 247553 Berndpauli Closest Approach To Earth (3.262 AU)
- May 21 - Cosmos (GLONASS 762, Uragan-M N45) Soyuz-2.1b/Fregat-M Launch
- May 21 - Comet 111P/Helin-Roman-Crockett Closest Approach To Earth (3.490 AU)
- May 21 - Asteroid 30857 Parsc Closest Approach To Earth (1.552 AU)
- May 21 - Plutino 38628 Huya At Opposition (27.569 AU)
- May 21 - Plutino 2006 HJ123 At Opposition (33.726 AU)
- May 22 - Cassini, Orbital Trim Maneuver #450 (OTM-450)
- May 22 - Mars At Opposition
- May 22 - Comet P/2001 H5 (NEAT) Closest Approach To Earth (2.045 AU)
- May 22 - Comet 111P/Helin-Roman-Crockett At Opposition (3.490 AU)
- May 22 - Asteroid 71885 Denning Closest Approach To Earth (1.502 AU)
- May 22 - Asteroid 727 Nipponia Closest Approach To Earth (1.868 AU)
- May 23 - Comet 289P/Blanpain At Opposition (3.672 AU)
- May 23 - Comet C/2014 OE4 (PANSTARRS) At Opposition (5.765 AU)
- May 24 - Galileo-FOC FM10 & FM11 Soyuz Launch
- May 24 - Apollo Asteroid 2009 DL46 Near-Earth Flyby (0.016 AU)
- May 24 - Amor Asteroid 2016 CF194 Near-Earth Flyby (0.053 AU)
- May 24 - Asteroid 14094 Garneau Closest Approach To Earth (1.948 AU)
- May 24 - Webinar: Bioenergetics and Habitability in Hydrothermal Systems and the Subseafloor
- May 24 - 35th Anniversary (1981), Discovery of Neptune Moon Larissa
- May 24 - Daniel Fahrenheit's 330th Birthday (1686)
Food for Thought

Europa's Ocean May Have An Earthlike Chemical Balance

A new NASA study modeling conditions in the ocean of Jupiter's moon Europa suggests that the necessary balance of chemical energy for life could exist there, even if the moon lacks volcanic hydrothermal activity.

Europa is strongly believed to hide a deep ocean of salty liquid water beneath its icy shell. Whether the Jovian moon has the raw materials and chemical energy in the right proportions to support biology is a topic of intense scientific interest. The answer may hinge on whether Europa has environments where chemicals are matched in the right proportions to power biological processes. Life on Earth exploits such niches.

In a new study, scientists at NASA's Jet Propulsion Laboratory, Pasadena, California, compared Europa's potential for producing hydrogen and oxygen with that of Earth, through processes that do not directly involve volcanism. The balance of these two elements is a key indicator of the energy available for life. The study found that the amounts would be comparable in scale; on both worlds, oxygen production is about 10 times higher than hydrogen production.

The work draws attention to the ways that Europa's rocky interior may be much more complex and possibly earthlike than people typically think, according to Steve Vance, a planetary scientist at JPL and lead author of the study. "We're studying an alien ocean using methods developed to understand the movement of energy"
and nutrients in Earth's own systems. The cycling of oxygen and hydrogen in Europa's ocean will be a major driver for Europa's ocean chemistry and any life there, just as it is on Earth."

Ultimately, Vance and colleagues want to also understand the cycling of life's other major elements in the ocean: carbon, nitrogen, phosphorus and sulfur.

As part of their study, the researchers calculated how much hydrogen that could potentially be produced in Europa's ocean as seawater reacts with rock, in a process called serpentinization. In this process, water percolates into spaces between mineral grains and reacts with the rock to form new minerals, releasing hydrogen in the process. The researchers considered how cracks in Europa's seafloor likely open up over time, as the moon's rocky interior continues to cool following its formation billions of years ago. New cracks expose fresh rock to seawater, where more hydrogen-producing reactions can take place.

In Earth's oceanic crust, such fractures are believed to penetrate to a depth of 3 to 4 miles (5 to 6 kilometers). On present-day Europa, the researchers expect water could reach as deep as 15 miles (25 kilometers) into the rocky interior, driving these key chemical reactions throughout a deeper fraction of Europa's seafloor.

The other half of Europa's chemical-energy-for-life equation would be provided by oxidants -- oxygen and other compounds that could react with the hydrogen -- being cycled into the Europan ocean from the icy surface above. Europa is bathed in radiation from Jupiter, which splits apart water ice molecules to create these materials. Scientists have inferred that Europa's surface is being cycled back into its interior, which could carry oxidants into the ocean.

"The oxidants from the ice are like the positive terminal of a battery, and the chemicals from the seafloor, called reductants, are like the negative terminal. Whether or not life and biological processes complete the circuit is part of what motivates our exploration of Europa," said Kevin Hand, a planetary scientist at JPL who co-authored the study.

Europa's rocky, neighboring Jovian moon, Io, is the most volcanically active body in the solar system, due to heat produced by the stretching and squeezing effects of Jupiter's gravity as it orbits the planet. Scientists have long considered it possible that Europa might also have volcanic activity, as well as hydrothermal vents, where mineral-laden hot water would emerge from the sea floor.

According to Vance, researchers previously speculated that volcanism is paramount for creating a habitable environment in Europa's ocean. If such activity is not occurring in its rocky interior, the thinking goes, the large flux of oxidants from the surface would make the ocean too acidic, and toxic, for life. "But actually, if the rock is cold, it's easier to fracture. This allows for a huge amount of hydrogen to be produced by serpentinization that would balance the oxidants in a ratio comparable to that in Earth's oceans," he said.

The results are published online this week in the journal Geophysical Research Letters.

Source: JPL
Space Image of the Week

Hubble Takes Mars Portrait Near Close Approach

Credit: NASA, ESA, the Hubble Heritage Team (STScI/AURA), J. Bell (ASU), and M. Wolff (Space Science Institute)

On May 12, 2016, astronomers using NASA's Hubble Space Telescope captured this striking image of Mars, when the planet was 50 million miles from Earth. The photo reveals details as small as 20 miles to 30 miles across. This observation was made just a few days before Mars opposition on May 22, when the sun and Mars will be on exact opposite sides of Earth. Mars also will be 47.4 million miles from Earth. On May 30, Mars will be the closest it has been to Earth in 11 years, at a distance of 46.8 million miles. Mars is especially photogenic during opposition because it can be seen fully illuminated by the sun as viewed from Earth.

Source: HubbleSite.org